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Juniper Control

INCREASES FORAGE PRODUCTION

ON THE FORT APACHE INDIAN RESERVATION

By

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C O N T E N T S

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2/ Forest Service, U. S. Department of Agriculture, with central headquarters maintained in cooperation with Colorado A & M College at Fort Collins, Colorado; research reported in this paper was conducted in cooperation with the University of Arizona and the Arizona State College at Flagstaff.

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INTRODUCTION

Forage and beef production are being restored on thousands of acres of rangelands on the Fort Apache Indian Reservation by the removal of invading juniper.[4/] Control of juniper has increased forage production tenfold on some areas.

Control, as used in this report, means man's attempt to stop the encroachment of juniper and pinyon into open grassland and to reclaim lands already invaded.

This encroachment has increased greatly since the arrival of white settlers and their grazing herds (3, 4).[5/] Before settlement, the spread of juniper was probably repressed by repeated wildfires. Charred tree stumps are common throughout the woodland ranges. Leopold (3), Parker (4), and Humphrey (1,2) have suggested that control of fires and the introduction of livestock that graze off the herbaceous cover and reduce inflammable fuels have decreased the number of wildfires. Thus, long-lived woody perennials such as juniper, pinyon, and associated species have been able to invade former productive open grasslands. These woody invaders suppress and reduce understory grasses and other herbaceous species. Although the continuing decline in forage production resulting from juniper encroachment has long been recognized by ranchers and technical range conservationists, until recent years few attempts have been made to control tree and shrub invasions.

In the past, economic conditions did not favor the control of invading trees and shrubs, but the present economic climate is more favorable. Clearing juniper from woodland ranges is becoming economically feasible because of the high prices for livestock products. Capital investments in juniper control will probably continue to increase because of the increasing demand for meat from rangelands. Clearing ranges of juniper and other woody species followed with proper stocking and other good management practices will help increase the productivity of many western ranges and thus contribute toward meeting the expected increase in consumer demands.

The encroachment of juniper has (1) reduced grazing capacities, (2) increased erosion, (3) increased the costs of handling livestock,

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4/ Common and botanical names of species mentioned are listed on page 34.

5/ Centerwall, W. R. Juniper and pinon pine eradication, and gully plugging, Fort Apache Indian Reservation. Typed report on file at Fort Apache Indian Agency, Whiteriver, Arizona. 9 pp., illus., 1940.

and (4) possibly decreased water yields (3, 4).[6/] Thus, many benefits may be realized from the control of juniper, but results reported here are largely confined to increases in forage yields.

LOCATION

The Fort Apache Indian Reservation covers 1,656,698 acres in the east-central part of Arizona just below the Mogollon Rim. Vegetation zones in the order of descending elevations include fir and ponderosa pine forests, pinyon-juniper woodlands, chaparral, desert grassland, and southern-desert shrub. Pinyon-juniper woodlands occupy about 80 percent of the reservation at intermediate elevations, mainly between 4,500 and 6,500 feet.

METHODS OF CONTROL

Juniper and pinyon stands were cleared from the treated areas mainly by chopping out the trees with hand axes although heavy equipment was tried on a limited scale. By 1953 the Fort Apache Indians had cleared approximately 60,000 acres in 8 years. Another 20,000 acres were treated in 1954. About 5 percent of the woodland area destined to receive treatment is being cleared annually. The Fort Apache Indians use hand clearing as a means for employing workers who would otherwise be idle during the off-season winter months.

Clearing rangelands of juniper by hand labor has several distinct advantages over the use of heavy equipment: (1) Hand chopping is much more thorough than cabling or dozing because small trees that often escape heavy equipment are removed along with the large trees; (2) hand chopping does not disturb the forage cover so much as cabling and uprooting equipment; and (3) hand labor can be used where ranges are too rough for heavy equipment.

The main disadvantage of chopping by hand is the expense. Cost of juniper eradication on the Fort Apache Indian Reservation averages $5 to $7 an acre where the wage scale is about $6 a day. These figures are slightly higher than the costs of dozing out individual trees and considerably higher than the average costs of cabling.

MEASURING THE EFFECTS OF CONTROL

Effects of juniper control on understory vegetation were determined by 50-foot line transects located in both the cleared areas and the adjacent untreated juniper stands at seven sites. Sites are named, and years of treatment with respect to clearing and protection are indicated by numerals that follow the names of the sites.

6/ Schroeder, William L. Juniper control. Mimeographed report on file at Fort Apache Indian Agency, Whiteriver, Arizona. 6 pp., 1951.

Transects were measured and clipped in late September of 1953. Densities were determined by measuring the linear basal intercepts of all herbaceous species. Vertical projections of canopies for all trees and shrubs were measured along transect lines to determine overstory intercepts. Junipers and pinyons within a 1/50-acre plot around each transect were counted to determine the tree-stand density. Herbage yields of grasses and forbs were determined by clipping a 4-inch strip at ground level along each 50-foot transect. These clippings were air dried, weighed, and converted to pounds per acre.

TREATMENT AND COMPARISONS OF PLANT COVER ON SITES SAMPLED

The seven sites sampled are somewhat similar in elevation, average annual precipitation, soils, and slopes. They differ in the number of trees per acre in the untreated stands. Treated areas differ in the dates of clearing, and in grazing treatment.

Comparisons of densities and compositions among the different sites are evaluated by classifying the individual species into five major plant-form groups, namely: (1) Superior overstory perennials (a. trees, and b. long-lived shrubs, yuccas, and cacti), (2) superior understory grasses (a. perennial midgrasses, and b. perennial short grasses), (3) inferior understory grasses and forbs (a. perennial tall, mid, and short forbs, and b. perennial prostrate grasses and forbs), (4) inferior short-lived half-shrubs, and (5) inferior annual grasses and forbs.7/

Kinishba 38 and 46

The Kinishba 38 and 46 sites (table 1) are about 5 miles west-southwest of Whiteriver, Arizona. The elevation is about 5,200 feet and precipitation averages 17 inches annually. The fine sandy loams of the area are derived from the sedimentary Supai formation. The area slopes to the south with an average gradient of about 3 percent.

Kinishba 38 was sampled by two transects within the exclosure that has protected the Kinishba Indian Ruins area from grazing since 1938. Transects were purposely located away from junipers and pinyons to provide a standard against which cleared areas could be compared. The transects, however, were influenced by long-lived overstory shrubs and yuccas.

Kinishba 46 is the open range outside the exclosure that was heavily grazed year round until about 1948. Since 1948 it has been moderately grazed by cattle and horses during the winter season only.

7/ Arnold, Joseph F. Plant life form, a basis for evaluating the ecological condition and trend of range communities within the ponderosa pine zone of Arizona. Manuscript in process of publication, 108 pp., 1955.

Table 1.-- Effects of juniper control under different grazing treatments at Kinishba 38 and 46 on principal species and plant forms, 1953

Principal species by plant-form classes [1/]	Kinishba 38: protected: since 1938,: untreated	Kinishba 46, mainly winter grazed: Untreated	Kinishba 46, mainly winter grazed: Juniper controlled, 1946
SUPERIOR OVERSTORY PERENNIALS			
Trees		(Per acre--number)	
One-seed juniper	0	50	0
		(Canopy intercept--percent)	
	0	12.33	0
Long-lived shrubs, yuccas, & cacti			
Salt-bush	2.50	0	.08
Shrubby buckwheat	.20	0	.07
Yuccas	0	3.80	1.67
Total	2.70	3.80	1.82
SUPERIOR UNDERSTORY GRASSES		(Basal intercept--percent)	
Perennial midgrasses			
Side-oats grama	1.10	.09	.73
Three-awns	1.22	.12	.01
Others	0	0	.09
Total	2.32	.21	.83
Perennial short grasses			
Blue grama	3.39	2.81	3.70
Texas-timothy	0	.91	.02
Total	3.39	3.72	3.72
INFERIOR UNDERSTORY GRASSES AND FORBS			
Perennial tall, mid, & short forbs			
Aster	0	Trace	.01
Perennial prostrate grasses & forbs			
Ring muhly	.04	2.07	4.73
Total	.04	2.07	4.74
INFERIOR SHORT-LIVED PERENNIALS		(Canopy intercept--percent)	
Half-shrubs			
Snake-weed	0	.07	0
INFERIOR ANNUAL GRASSES AND FORBS		(Basal intercept--percent)	
Spurges	0	Trace	0
Russian-thistle	0	0	.02
Total	0	Trace	.02
Air-dry herbage yields of grasses and forbs (pounds per acre)	586	630	612
Number of transects	2	6	6

1/ Botanical names of species are listed on page 34.

The untreated woodland range of Kinishba 46 supported a light stand of one-seed juniper. The treated area was cleared of juniper in 1946. Six transects were measured in each of the treated and untreated areas.

The difference between Kinishba 38 and Kinishba 46 is mainly a difference between protection and grazing. Juniper had little effect on the understory vegetation because it occurred in very light stands both within the exclosure and on the outside untreated area. The difference between protection and grazing was evident by the abrupt fence-line differences in plant composition. Palatable long-lived shrubs such as chamize or four-wing salt-bush, shrubby buckwheat, and winter-fat were abundant within the protected area and sparsely scattered on the open range. Though abundant within the exclosure, winter-fat was not measured on the transects. Perennial grasses that are susceptible to grazing injury showed high basal intercepts within the exclosure and low intercepts outside the fence. Short grasses like blue grama and Texas-timothy, because they can withstand fairly heavy use, occupied about as much area outside as inside the exclosure. Ring muhly, a prostrate grass generally favored by grazing, made up a large portion of the herbaceous cover outside the fence but was barely measurable within the exclosure. Inferior understory forbs, short-lived half-shrubs, and annuals were so sparse that they were not even recorded by the transects within the exclosure.

The effect of juniper control on the understory plant cover on this area is illustrated by comparing cleared and untreated areas of Kinishba 46. Differences between plant cover on cleared and untreated areas are not great because the original stand of overstory trees was light. The untreated stand averaged only 1 tree per 1/50-acre plot or 50 trees per acre. However, some differences did occur.

Perennial midgrasses and prostrate ring muhly show considerably higher densities on the cleared area, while short grasses are about the same for treated and untreated sites.

Samples of air-dry herbage yields of grasses and forbs showed little difference between the cleared and untreated light stands. However, some plants showed evidence of current grazing on the cleared area. The average herbage yield of grasses and forbs for the two samples collected within the Kinishba 38 exclosure was lower than that of the outside area, possibly because of the somewhat greater competition from long-lived overstory shrubs such as salt-bush and shrubby buckwheat.

Canyon Day 53, 52, 51, and 50

The Canyon Day sites (table 2) were located 3 to 6 miles directly southwest of Whiteriver and south of the Kinishba sites. Physical conditions of the Canyon Day sites were similar, the general

Table 2.-- Effects of juniper control on principal plants and life forms at Canyon Day sites 53, 52, 51, and 50 that are mainly grazed in winter. 1953

Principal species by plant-form classes	Untreated	Juniper controlled 1953	1952	1951	1950
SUPERIOR OVERSTORY PERENNIALS					
Trees		(Per acre--number)			
Junipers & pinyon	25.5	0	10.0	0	0
		(Canopy intercept--percent)			
	17.33	0	.67	0	0
Long-lived shrubs, yuccas, & cacti					
Squaw-bush	.36	0	.50	0	0
Yuccas	.31	0	1.40	1.13	0
Prickly-pears	.09	0	0	0	0
Total	.76	0	1.90	1.13	0
SUPERIOR UNDERSTORY GRASSES		(Basal intercept--percent)			
Perennial midgrasses					
Side-oats grama	.87	.57	1.74	2.60	1.95
Three-awns	.02	0	.08	.05	.01
Black grama	0	0	0	.14	0
Others	.01	0	.03	.06	0
Total	.90	.57	1.85	2.85	1.96
Perennial short grasses					
Blue grama	.64	1.02	1.76	2.30	1.55
Hairy grama	.48	0	.04	0	0
Creeping muhly	.34	0	0	0	0
Texas timothy	.05	0	0	.08	0
Others	0	0	0	.04	0
Total	1.51	1.02	1.80	2.42	1.55
INFERIOR UNDERSTORY GRASSES AND FORBS					
Perennial tall, mid, & short forbs					
Asters	.01	.03	.04	.05	0
Desmanthus	.01	0	0	0	.09
Globe-mallows	0	0	0	.13	0
Wild-buckwheats	Trace	0	.05	0	0
Others	.02	.04	0	.01	.10
Total	.04	.07	.09	.19	.19
Perennial prostrate grasses & forbs					
Ring muhly	0	0	.03	2.32	0
INFERIOR SHORT-LIVED PERENNIALS		(Canopy intercept--percent)			
Half-shrubs					
Snake-weed	.38	.95	6.47	.70	0
Twin-berry	.32	0	.14	.25	.03
Others	0	0	0	0	.50
Total	.70	.95	6.61	.95	.53

(Table 2 continued on page 8)

Table 2 (continued)

Principal species by plant-form classes	Untreated	Juniper controlled 1953	1952	1951	1950
INFERIOR ANNUAL GRASSES AND FORBS		(Basal intercept--percent)			
Spurges	.01	.04	.01	.06	.19
Resin-weed	.01	.01	.27	0	0
Russian-thistle	0	.63	0	0	0
Others	.05	.02	.08	.01	.04
Total	.07	.70	.36	.07	.23
Air-dry herbage yields of grasses & forbs (pounds per acre)	222	175	320	396	1/255
Number of transects	14	4	6	6	6

1/ Value does not represent season's growth because area had been grazed rather heavily during summer.

elevation being about 5,300 feet, annual precipitation averaging about 17 inches, and slope gradients averaging 5 percent with south and southwest exposures. Soils were sandy loams of the same origin as those at the Kinishba sites.

The cleared Canyon Day sites are shown in table 2 in the inverse order of the years when they received treatment, to line them up according to the number of growing seasons since clearing. Canyon Day 53, which was cleared in 1953, is represented by 4 transects. No adjacent juniper stands were available for samples of an untreated area. At Canyon Day 52, 6 transects were measured in the area cleared in 1952 and 6 were measured in the adjacent untreated juniper stands. At Canyon Day 51, 6 transects were measured in the area cleared of juniper in 1951 and 6 in the adjacent untreated woodland range. Six transects were measured in the area cleared in 1950 at Canyon Day 50 and 2 in the untreated area. All transect samples measured in the untreated stands were averaged to provide a single basis against which the 4 treated areas could be compared. In addition to one-seed juniper, overstory trees at the 4 sites also included Utah juniper, alligator juniper, and pinyon.

All Canyon Day sites were heavily grazed yearlong until about 1948. Thereafter the sites received moderate winter grazing. However, Canyon Day 50 received considerable use during the 1953 summer season from transient livestock that were often herded along a nearby road. Because of grazing that had occurred at the time samples were taken, the average herbage yield for Canyon Day 50 is omitted in later summarizations.

Comparison of juniper-controlled areas with untreated stands suggests that midgrasses have increased since clearing. Canyon Day 50 is the exception in this general trend, probably because of its nearness to a main-traveled road and the subsequently greater amount of grazing it received. In any event, densities of midgrasses on the cleared areas that have gone through two or more growing seasons were higher than those of the untreated sites. Densities of perennial short grasses in 1953 were generally higher on the sites after two or more growing seasons following juniper control. The density of perennial forbs also showed a general increase with the number of seasons following juniper control. Snake-weed, the principal short-lived half-shrub, appeared to have increased rapidly after it was released by the clearing of overstory trees and showed the greatest canopy intercept at the end of the second growing season at Canyon Day 52. By the end of the third and fourth growing seasons at Canyon Day 51 and 50, snake-weed appeared to have decreased. Annuals had their greatest density by the end of the first growing season at Canyon Day 53 and tended to be less as the number of growing seasons after clearing increased.

Herbage yields as sampled in 1953 showed a tendency to increase with the lapse of time since clearing except at Canyon Day 50 where the samples were not representative of the season's growth because of grazing.

Grasshopper 49

The Grasshopper 49 site (table 3) is 40 miles west of White-river at an elevation of 5,600 feet. Annual precipitation averages 20 inches. Slope averages about 3 percent and has a southwest exposure. Soils are sandy loams derived from Redwall and related limestone formations.

The area was heavily grazed until 1949. Range conditions were so poor that grazing animals were removed from the range at the time juniper control was initiated in 1949, and the area was then protected from domestic stock through 1953.

Four transects were measured in the cleared area and six in the adjacent untreated stands of juniper. The untreated juniper stand was very heavy, averaging 9.5 trees per 1/50 acre or 475 trees per acre.

The density of blue grama, a perennial short grass, on the cleared area was almost 19 times greater in 1953 than that of the untreated juniper stands (fig. 1). Although no midgrasses were recorded on the transects, species such as side-oats grama and mid-statured three-awns were quite abundant in parts of the treated area. Inferior perennial forbs and annuals showed considerably higher densities on the cleared areas.

Table 3.-- Effects of juniper control at Grasshopper 49 on principal species and plant forms under protection from grazing since 1949. 1953

Principal species by plant-form classes	Untreated	Juniper controlled, 1949
SUPERIOR OVERSTORY PERENNIALS		
Trees	(Per acre--number)	
One-seed juniper	475	0
	(Canopy intercept--percent)	
	52.73	0
Long-lived shrubs and cacti		
Shrubby penstemon	.03	0
Shrubby buckwheat	0	.02
Prickly-pears	.18	0
Total	.21	.02
SUPERIOR UNDERSTORY GRASSES	(Basal intercept--percent)	
Perennial midgrasses		
Mutton grass	.03	0
Squirrel-tail	.02	0
Total	.05	0
Perennial short grasses		
Blue grama	.49	9.20
INFERIOR UNDERSTORY GRASSES AND FORBS		
Perennial tall, mid, and short forbs		
Wild-buckwheats	.01	0
Globe-mallow	0	.06
Others	0	.07
Total	.01	.13
Perennial prostrate grasses and forbs	0	0
INFERIOR SHORT-LIVED PERENNIALS	(Canopy intercept--percent)	
Half-shrubs	0	0
INFERIOR ANNUAL GRASSES AND FORBS	(Basal intercept--percent)	
Spurges	.06	.38
Aplopappus	0	.10
Resin-weed	0	.02
Others	0	.01
Total	.06	.51
Air-dry herbage yields of grasses and forbs (pounds per acre)	51	550
Number of transects	6	4

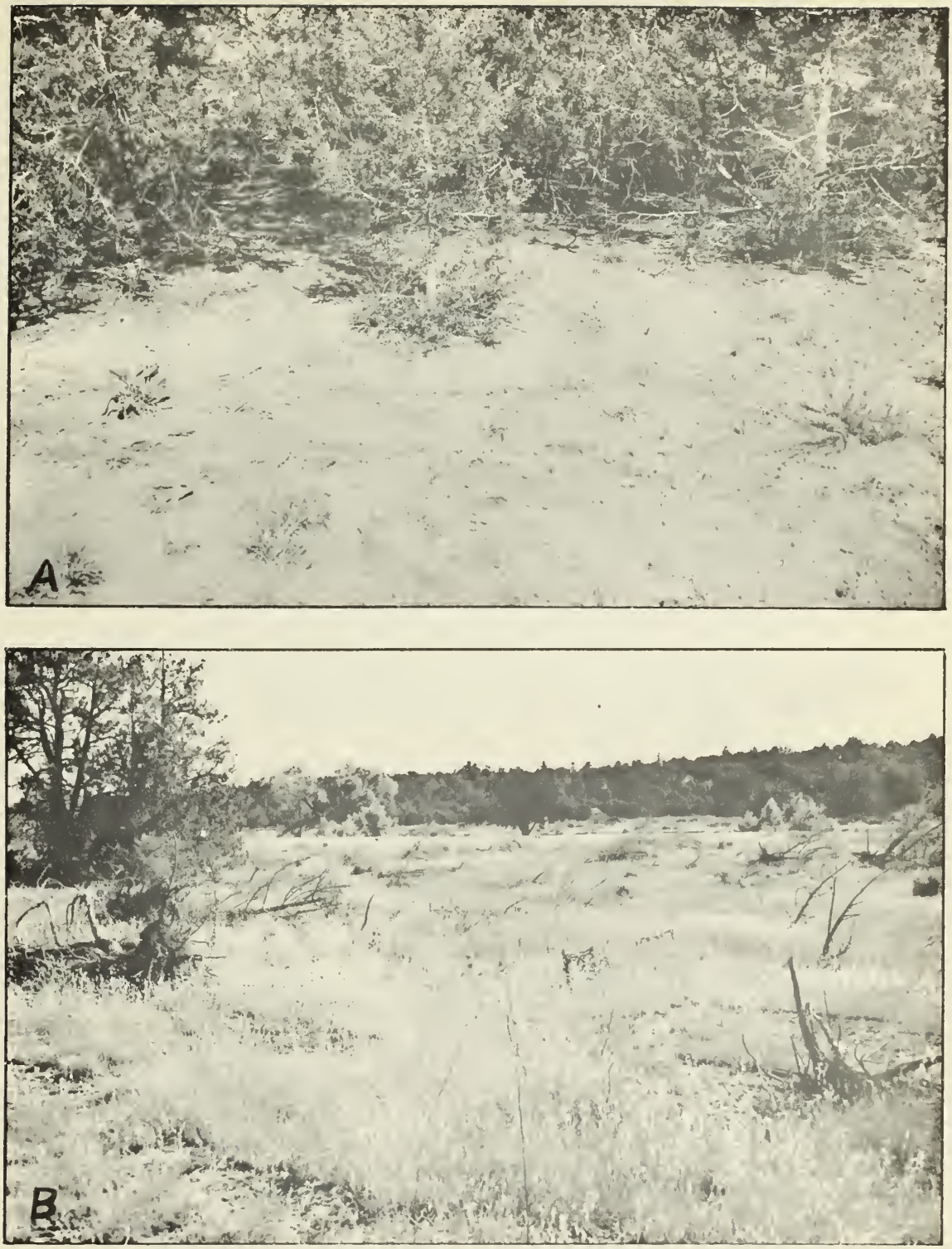

Figure 1.-- A. Untreated juniper stand. B. Area cleared of juniper in 1949. Both photographs were taken at Grasshopper from the same camera point, the camera being rotated 180° between A and B. Grazing has been withheld from both treated and untreated areas from 1949 through 1953.

Air-dry herbage yields of grasses and forbs on the cleared area averaged about 10 times the yields from the untreated woodland stands.

Stinking Springs 48

Stinking Springs 48 (table 4) is 15 miles northwest of Whiteriver at an elevation of 5,400 feet. Annual precipitation averages 18 inches. The site slopes to the east with an average gradient of 5 percent.

Stinking Springs was heavily grazed in the past but is presently used more lightly and mainly during the winter season. The site had been grazed considerably during the summer of 1953. Juniper and pinyon were cleared from the treated area in 1948.

Woodland stands of the untreated area included an overstory mixture of one-seed juniper, Utah juniper, and pinyon pine. A mixed shrubby understory included Baccharis, shrubby buckwheat, several species of yucca, bear-grass, and several species of prickly-pear. Yuccas and bear-grass were left on the area cleared of overstory trees.

Six transects were measured in the cleared area and six in the untreated woodland stands. Densities of midgrasses and short grasses on the treated areas were several times greater than on the untreated area. Ring muhly, a prostrate perennial, and annuals showed somewhat greater densities on the cleared area.

Air-dry herbage yields represented only a part of the 1953 season's growth since the area had been grazed during the summer. The average yield from the cleared area was four times greater than that of the untreated area. Because of grazing, herbage yields of Stinking Springs are omitted from summary analyses that follow.

A marked difference in the amounts of active sheet and gully erosion was noted between cleared and untreated areas (fig. 2). Transects in the cleared area intercepted no active gullies; erosion was largely arrested by a good density of short grasses. Transects in the untreated woodland stands intercepted 22 active gullies in the combined length of six 50-foot lines. Out of a total of 300 feet of line, shallow gullies intercepted about 145 feet. This is particularly impressive since the transects in the untreated woodland area were continued along the same contour on which the transects in the treated area were located. There were no apparent site differences other than the presence of juniper.

Table 4.-- Effects of juniper control at Stinking Springs 48[1/] on principal species and plant forms. 1953

Principal species by plant form classes	Untreated	Juniper controlled, 1948
SUPERIOR OVERSTORY PERENNIALS		
Trees	(Per acre--number)	
Juniper and pinyon	240	0
	(Canopy intercept--percent)	
	15.70	0
Long-lived shrubs, yuccas, and cacti		
Baccharis	.27	0
Shrubby buckwheat	0	.67
Yuccas	3.67	0
Bear-grass	.88	.87
Prickly-pears	1.38	0
Total	6.20	1.54
SUPERIOR UNDERSTORY GRASSES	(Basal intercept--percent)	
Perennial midgrasses		
Side-oats grama	.03	.06
Galleta	.13	0
Three-awns	0	.01
Black grama	0	.38
Others	.01	.06
Total	.17	.51
Perennial short grasses		
Blue grama	.68	5.33
Texas-timothy	.01	.08
Total	.69	5.41
INFERIOR UNDERSTORY GRASSES AND FORBS		
Perennial tall, mid, and short forbs		
Aster	.01	.01
Others	0	.03
Total	.01	.04
Perennial prostrate grasses and forbs		
Ring muhly	0	.10
INFERIOR SHORT-LIVED PERENNIALS	(Canopy intercept--percent)	
Half-shrubs		
Snake-weed	.20	0
Twin-berry	.05	0
Total	.25	0

Table 4 continued on page 14

Table 4 (continued)

Principal species by plant-form classes	Untreated	Juniper controlled, 1948
INFERIOR ANNUAL GRASSES AND FORBS	(Basal intercept--percent)	
Spurges	.01	.38
Others	0	.05
Total	.01	.43
Air-dry herbage yields of grasses and forbs (pounds per acre)	2/74	2/298
Number of transects	6	6

1/ Although area is grazed mainly in winter, it received considerable use during the current summer.

2/ Value does not represent season's growth because of summer grazing.

Cedar Creek 41 and 49

The general site of Cedar Creek 41 and 49 (table 5) is 12 miles west of Whiteriver at an elevation of 5,200 feet. Annual precipitation averages 17 inches. Soils of the site are fine sandy loams derived from Supai formation. The terrain slopes to the southwest with an average gradient of 3 percent.

A fenced exclosure was erected at Cedar Creek in 1940. Half of the exclosure was cleared of overstory trees in 1941. Juniper was controlled in 1949 on the adjacent outside range. Two transects were measured in the cleared protected area, four in the untreated juniper stands under protection, and two on the juniper-controlled area outside the exclosure. Untreated woodland stands open to grazing were unavailable for sampling within the immediate area.

The open range outside the exclosure was subject to extremely heavy yearlong grazing until 1949, when the season of use for the range as a whole was changed to lighter grazing in winter. But the local area around the Cedar Creek exclosure received considerable use during the summer from transient livestock that were herded along a main-traveled road near the site.

Comparisons of the three treatments indicate that the density of midgrasses was highest for the cleared and protected area, next highest for the untreated juniper stands under protection, and least for the cleared outside range. Densities for short grasses were highest for the cleared protected area and the same for the untreated

Table 5.-- Effects of juniper control under protection and grazing at Cedar Creek 41 and 49 on principal species and plant forms. 1953

Principal species by plant-form classes	Protected since 1940 : Untreated	Protected since 1940 : Juniper controlled, 1941	Grazed, 1/ : Juniper controlled, 1949
SUPERIOR OVERSTORY PERENNIALS			
Trees		(Per acre--number)	
One-seed juniper	150	0	0
		(Canopy intercept--percent)	
	26.50	0	0
Long-lived shrubs			
Shrubby buckwheat	1.18	0	3.50
SUPERIOR UNDERSTORY GRASSES		(Basal intercept--percent)	
Perennial midgrasses			
Three-awns	.13	1.42	.03
Squirrel-tail	.01	0	0
Others	0	0	.06
Total	.14	1.42	.09
Perennial short grasses			
Blue grama	1.60	3.79	1.67
Creeping muhly	.07	0	0
Total	1.67	3.79	1.67
INFERIOR UNDERSTORY GRASSES AND FORBS			
Perennial tall, mid, and short forbs	0	0	0
Perennial prostrate grasses and forbs			
Ring muhly	1.29	.85	4.46
INFERIOR SHORT-LIVED PERENNIALS		(Canopy intercept--percent)	
Half-shrubs	0	0	0
INFERIOR ANNUAL GRASSES AND FORBS		(Basal intercept--percent)	
Spurges	0	.08	.01
Air-dry herbage yields of grasses and forbs (pounds per acre)	196	686	2/-
Number of transects	4	2	2

1/ Although the surrounding range is grazed mainly in winter, the area around the exclosure was grazed quite heavily during the summer of 1953.

2/ No data because of grazing.

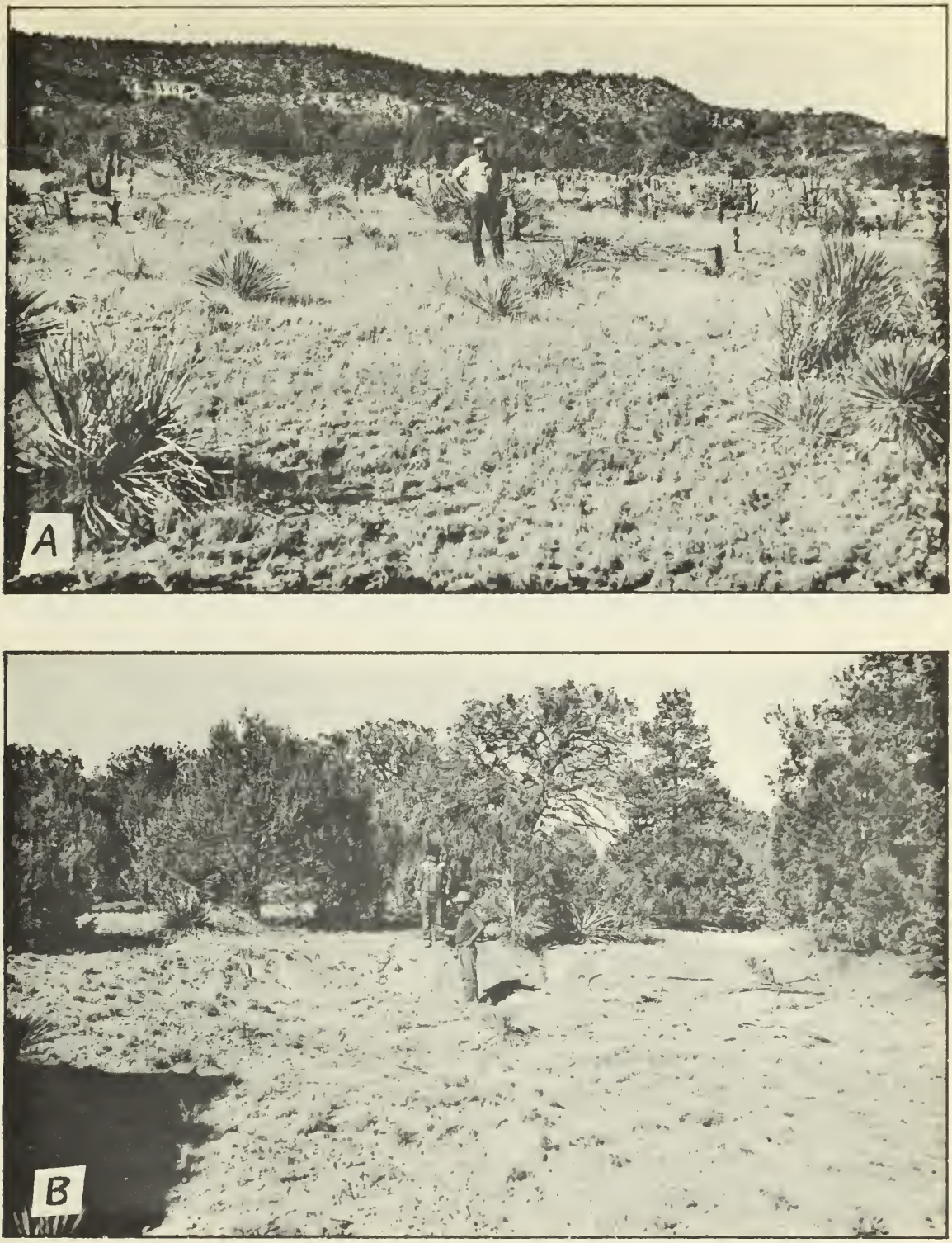

Figure 2.-- A. Area cleared of juniper at Stinking Springs in 1948 has a good grass cover and no gullies. B. The untreated woodland area has a sparse cover of grass and numerous small gullies.

protected juniper stands and the cleared outside range. Ring muhly showed its highest density on the cleared outside range and the lowest density on the cleared area under protection. Ring muhly was apparently unable to withstand competition from superior perennial grasses and consequently was largely replaced by midgrasses and short grasses on the cleared area under protection. Shrubby buckwheat showed a much higher intercept on the cleared outside range, possibly because here it was without competition from perennial midgrasses and short grasses.

Under protection from livestock the average herbage yield from the cleared area was $3\frac{1}{2}$ times that of the untreated juniper stand. Samples of herbage yields were unavailable for the outside range because of grazing.

East Fork Settlement

East Fork Settlement (table 6) is 3 miles southeast of Whiteriver at an elevation of 5,200 feet. Annual precipitation averages 17 inches. Soils are fine sandy loams derived from the Supai geological formation. The general terrain slopes to the southwest with an average gradient of 3 percent.

The area is heavily grazed throughout the year by saddle stock and animals kept in the nearby Indian settlement. The area was selected as an example of one receiving heavy yearlong grazing. Samples of herbage yields were unavailable because of grazing.

Overstory trees were cleared from the area in 1951. Untreated juniper stands were unavailable for sampling within the immediate vicinity of the site.

Measurements of the two transects indicate a very low density of midgrasses, a fairly low density of perennial short grasses, a fairly high density of prostrate perennials, and a very high canopy intercept of short-lived half-shrubs. Compared to the other sites that were grazed mainly in winter, heavy yearlong grazing favored such inferior short-lived half-shrubs as snake-weed and twin-berry and inferior prostrate perennials such as ring muhly.

Table 6.-- Effects of juniper control at East Fork Settlement 51 on principal species and plant forms under heavy yearlong grazing. 1953

Principal species by plant-form classes	Juniper controlled, 1951
SUPERIOR OVERSTORY PERENNIALS	
Trees	0
	(Canopy intercept--percent)
Long-lived shrubs	
Shrubby buckwheat	1.10
SUPERIOR UNDERSTORY GRASSES	(Basal intercept--percent)
Perennial midgrasses	
Side-oats grama	.14
Sand drop-seed	.38
Total	.52
Perennial short grasses	
Blue grama	2.56
INFERIOR UNDERSTORY GRASSES AND FORBS	
Perennial tall, mid, and short forbs	
Aster	.55
Globe-mallows	.04
Total	.59
Perennial prostrate grasses and forbs	
Ring muhly	1.29
INFERIOR SHORT-LIVED HALF-SHRUBS	(Canopy intercept--percent)
Snake-weed	1.30
Twin-berry	2.00
Total	3.30
INFERIOR ANNUAL GRASSES AND FORBS	(Basal intercept--percent)
Aplopappus	.01
Air-dry herbage yields of grasses and forbs (pounds per acre)	1/ -
Number of transects	2

1/ No data, grazed too heavily.

JUNIPER CONTROL RELEASES UNDERSTORY PLANTS

Comparisons of summarized results in figure 3 indicate the extent to which understory plants were released by the clearing of overstory trees on both protected and grazed areas. Values used to construct the chart are weighted averages for the combined individual transects.

Because the Kinishba 38 area has been protected for 15 years, the herbaceous plant cover represents a high stage of ecological succession. It can be used as a standard of comparison for evaluating the plant composition of the juniper-controlled and untreated areas. The herbaceous cover is dominated by perennial midgrasses and short grasses. Prostrate grasses like ring muhly occurred in only trace amounts while no intercepts were recorded for annuals and short-lived half-shrubs.

A comparison of the juniper-controlled and untreated areas under protection from grazing at Cedar Creek 41 and Grasshopper 49 shows that by 1953 the release of understory grasses and forbs after the removal of juniper resulted in a total density five times the herbaceous density of the untreated areas. The herbaceous plant cover appears to be in a stage of succession approaching that of Kinishba 38. It is dominated by perennial short grasses with small amounts of prostrate perennials and annuals. The transects intercepted no short-lived half-shrubs.

It is anticipated that further successional changes of the juniper-controlled area will result in a partial displacement of short grasses by midgrasses. The total herbaceous density of the juniper-controlled areas is probably higher than that of Kinishba 38 because there were practically no long-lived shrubs at the cleared Cedar Creek and Grasshopper sites. Long-lived shrubs may eventually invade the controlled areas as they have the Kinishba area.

Juniper control on the grazed areas resulted in a cover of understory plants that was almost twice that under the untreated juniper stands. Densities of all herbaceous plant forms and the canopy intercepts of half-shrubs were all greater on the areas cleared of juniper. Short-lived half-shrubs and prostrate species, notably lacking under protection, were common on the grazed areas. In comparison with the standard at Kinishba 38, annuals, short-lived half-shrubs, and prostrate species like ring muhly were more abundant on grazed areas.

SUCCESSIONAL CHANGES AFTER JUNIPER CONTROL

Successional displacement of inferior herbaceous plants by ecologically superior plant forms is indicated by the chronological arrangement of juniper-control treatments on grazed areas in figure 4. The bar showing composition of the understory vegetation for Kinishba 38 is included at the top of the graph for comparison.

Stages of successional recovery are indicated by the relation of each of the treated sites to the Kinishba area.

Annuals were most abundant after the first growing season following juniper removal at Canyon Day 53. They were still fairly abundant after 2 growing seasons following clearing at Canyon Day 52 but occurred only in minor amounts on Canyon Day 51 that had been cleared for 3 years. They were present in measurable amounts after 4 seasons following clearing at Canyon Day 50 and 6 seasons at Stinking Springs 48. Here, the perennial grasses received considerable grazing use during the current summer.

Short-lived half-shrubs occurred in greatest abundance in 1953 at the end of the second growing season following the removal of juniper at Canyon Day 52. Half-shrubs were also abundant at the end of the third growing season at East Fork 51, but their abundance at this site was undoubtedly favored by heavy yearlong grazing. Generally they appear to be displaced by perennial grasses after 3 or 4 growing seasons following juniper control.

Prostrate perennials such as ring muhly showed a tendency to increase after 2 growing seasons following the control of juniper. They were most abundant at Kinishba 46 after 8 growing seasons following control. Canyon Day 50 and Stinking Springs, where perennial midgrasses and short grasses made up most of the density, were exceptions to the general trend.

Perennial short grasses showed no marked differences until after 5 or more growing seasons following the removal of juniper. The density of short grasses was greatest at Stinking Springs 48 and Kinishba 46 where 6 and 8 growing seasons had passed since clearing.

The densities of midgrasses showed a pattern that increased with the number of growing seasons after juniper control at Canyon Day 53, 52, and 51, the sites most similar with respect to location, treatment, and grazing use. The density of midgrasses at Canyon Day 50 was not so high as Canyon Day 51, probably because of the heavier grazing use it received. The lowest densities of midgrasses were recorded at East Fork 51, Cedar Creek 49, and Stinking Springs 48, the sites grazed most heavily in summer. This indicates the high susceptibility of midgrasses to grazing injury. The low density of midgrasses at Kinishba 46 indicates a slow rate of replacement where midgrasses must replace high densities of perennial short grasses and prostrate species.

In spite of differences among sites with respect to (1) the density of overstory trees before removal, (2) the intensity of past grazing use, and (3) present grazing, the replacement of inferior plants by superior plant forms indicates in general an orderly pattern of succession. Annuals appear to increase most rapidly during the first season following juniper control. Short-lived half-shrubs increase greatly during the second and third growing seasons following juniper

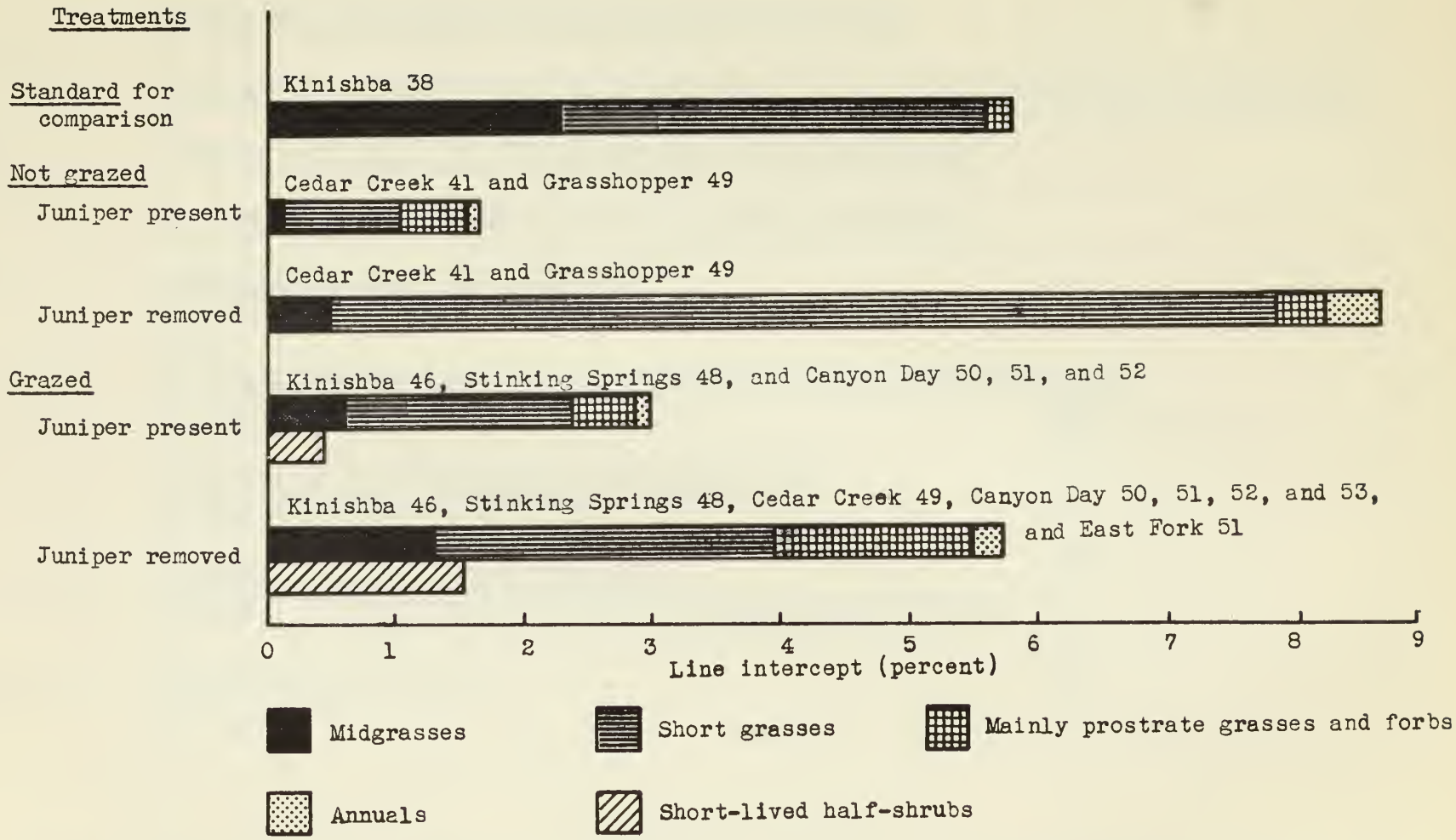

Figure 3.--Effects of juniper control and grazing on density of understory grasses and forbs and the canopy intercepts of short-lived half-shrubs.

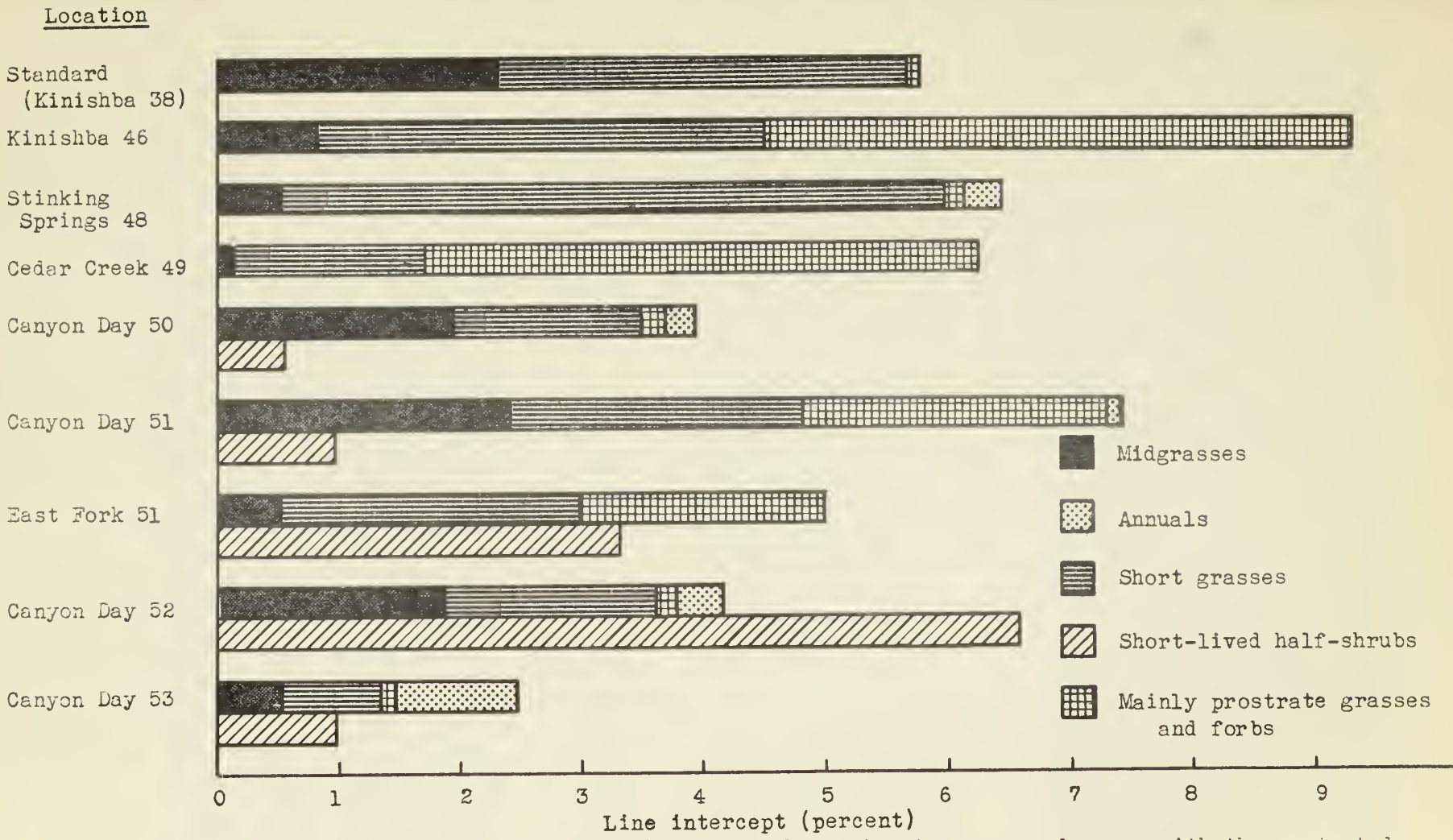

Figure 4.--A chronological comparison of juniper-control treatments on grazed areas with the protected area at Kinishba 38 indicates the relation of plant form to time since treatment.

control. Annuals and short-lived half-shrubs appear to be replaced by prostrate perennials and short grasses and midgrasses after fourth and fifth seasons following juniper control. Although short grasses and midgrasses may replace annuals, short-lived half shrubs, and prostrate species by the end of the sixth growing season, the rate of replacement may be prolonged by heavy yearlong grazing as indicated by Cedar Creek 49 and East Fork 51. The rate of successional replacement may approach the herbaceous cover represented by Kinishba 38 more rapidly under protection, as is indicated by the juniper-controlled areas under protection at Cedar Creek 41 and Grasshopper 49 in figure 3. Overstory trees and shrubs will likely reinvade the juniper-controlled areas in time, as may be evidenced where juniper, pinyon, sagebrush, and rabbitbrush have reinvaded many old burned-over sites that were once swept clean by wildfires.

HERBAGE YIELDS FROM UNTREATED JUNIPER STANDS

The relationship between herbage yields and stand densities of overstory trees on untreated areas is graphically illustrated in figure 5. Samples for herbage yields from untreated areas, either protected or grazed only in winter, are shown for different tree-stand densities as indicated by the number of trees per acre. Samples of herbage yields collected at Stinking Springs are omitted from the graph because they did not represent a full season's growth. Two of the Canyon Day points are located at fractional distances between tree classes because a single sample at both the 150- and 350-tree classes was averaged in with the samples for the 100- and 300-tree classes respectively.

The pattern of points in figure 5 reflects, in general, the relationship between air-dry herbage yields and the number of trees per acre even though the number of transect samples in each tree class is too limited to permit a regression analysis.

Herbage yields were inversely related to the number of trees on the areas studied. Differences in herbage yields were much greater on areas with up to 200 trees per acre and less as the number of trees increase from 250 to 800 per acre. Tree stands at the Kinishba 46, Canyon Day, and Cedar Creek sites were more uniform in both size and age than the mixed stands of large and small trees at Grasshopper. This may account in part for the lower yields at Grasshopper. Although no trees grew within measuring distance of the transects at Kinishba 38, long-lived shrubs, yuccas, and cacti averaged about 375 plants per acre. This was considerably higher than the number of understory shrubs in the adjacent untreated woodland stands at Kinishba 46. Sampled yields at Kinishba 38 may have been lower than the yields at Kinishba 46 because of this high population of long-lived shrubs, yuccas, and cacti.

RATE OF INCREASE OF HERBAGE YIELDS FOLLOWING JUNIPER CONTROL

The rate at which herbage yields increase following juniper control under protection or under winter grazing is indicated in figure 6. In this figure yield samples from each of six sites are plotted against the number of growing seasons since clearing. Herbage yields of cleared areas at Canyon Day 50 and Stinking Springs 48 were omitted because they had been grazed prior to clipping.

The slope of the curve indicates that the average rate of increase in herbage yields dropped from 82 pounds per acre between the first and second growing seasons after clearing to 32 pounds per acre between the seventh and eighth growing seasons. The slope of the yield curve increased most rapidly for the first eight seasons of growth following clearing and then tapered off at a level which would indicate a productive potential of 650 to 700 pounds per acre.

The curve indicates the rate at which forage yields can be brought to a maximum sustained level of production under winter grazing. On the basis that it takes 10 years to reach maximum production under winter use, the Fort Apache Indians could reasonably expect to bring that part of their woodland-range area which they plan to clear of juniper up to a maximum sustained level of production in 30 years providing (1) they continue to clear 5 percent each year, (2) they maintain the cleared areas against reinvasions, and (3) they continue winter grazing. An added margin of 5 to 10 years may be more realistic to allow for years of drought when the rate of recovery may be slowed measurably.

On the basis of these studies it seems likely that the grazing capacity will be increased on the cleared ranges after full recovery of the vegetation in proportion to the indicated increases in herbage yields. If air-dry herbage yields average 200 pounds per acre for the untreated woodland ranges (a conservative estimate for the ranges studied) and can be increased to 600 pounds per acre, and since the composition of the herbage will be improved, it seems reasonable to expect a threefold increase in grazing capacity by the end of 35 to 40 years where 5 percent of the woodland range is treated each year. This estimate cannot be applied equally to ranges grazed yearlong because the expected rate of recovery would be much slower.

SUMMARY

Indians on the Fort Apache Reservation in eastern Arizona have found the clearing of juniper by hand chopping to be economical because it provides employment during the off-season winter months and because it will increase the returns from livestock enterprises to individuals and to the tribe in general.

Effects of juniper control were evaluated at 7 sites where clearing was done over a period of 13 years. In addition to the time of clearing, grazing treatments also varied among the sites.

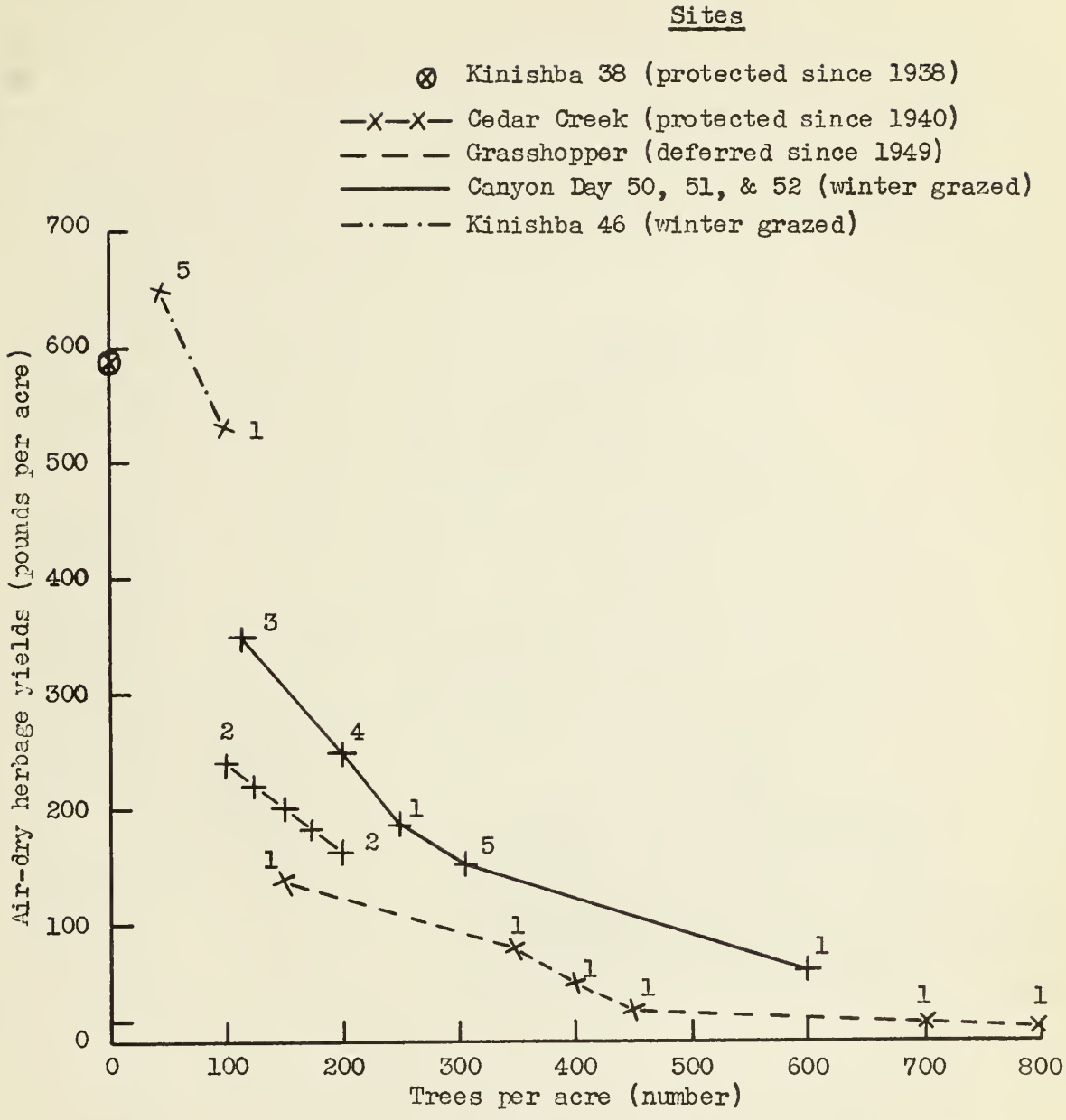

Figure 5.--Relationship between herbage yields and number of pinyon and juniper trees per acre on untreated sites that were either protected or winter grazed. Numerals indicate the number of transects used to locate each point.

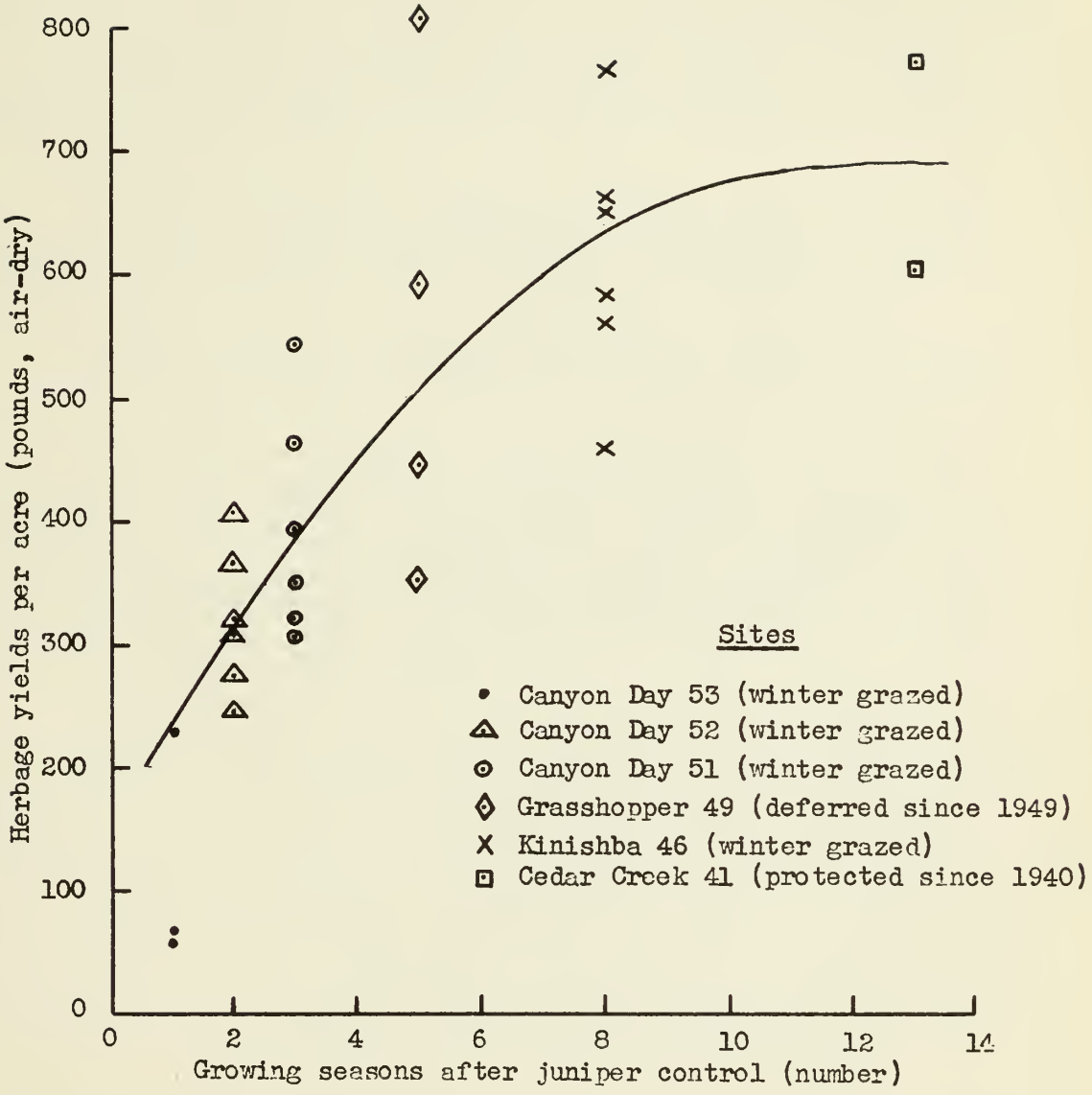

Figure 6.--Rate at which herbage yields increased by number of growing seasons after juniper was controlled on protected and winter-grazed sites.

Basal densities of herbaceous vegetation and crown spread of shrubs and trees were measured on the study areas, using 50-foot line transects. Herbage yields of grasses and forbs were determined by weighing air-dried samples obtained by clipping a 4-inch strip along each transect to ground level.

A plant-form classification indicating ecological superiority and inferiority with respect to competition, dominance, and succession was used in comparing the vegetation on cleared and untreated areas. Plant forms listed in descending order of ecological superiority were: (1) Long-lived trees, (2) long-lived shrubs, yuccas, and cacti, (3) perennial midgrasses, (4) perennial short grasses, (5) perennial grasses and forbs, mainly prostrate perennials, (6) short-lived half-shrubs, and (7) annuals.

A chronological arrangement of juniper-control treatments on grazed areas indicated in general that, following control, ecologically superior plants tend to displace ecologically inferior plants in the reverse order of the plant-form classification.

Herbage yields of grasses and forbs from untreated woodland stands decreased as the number of overstory trees per acre increased.

The rate of increase in herbage yields following juniper-control treatments was indicated by a chronological evaluation of yields from treated areas that were either protected or winter grazed. Areas that had been cleared for 2 growing seasons produced an average of 82 pounds of herbage per acre more than the areas cleared for 1 growing season. After 8 growing seasons the average increase in herbage yield tapered off at a productive level of about 650 to 700 air-dry pounds per acre.

The Fort Apache Indians can expect to increase forage production threefold in 35 to 40 years on that part of their woodland-range area which they plan to clear providing (1) they continue to clear 5 percent each year, (2) they maintain the cleared areas against reinvasions, and (3) they continue winter grazing. This estimate is based on the assumption that a maximum sustained level of production can be achieved by clearing on winter-grazed ranges. It also allows for drought years when recovery may be slowed. The estimated period required to bring the cleared areas to a maximum level of production is likely to be shortened, because the Apache Indians are beginning to clear more than their past average of 5 percent each year.

COMMON AND BOTANICAL NAMES OF SPECIES LISTED BY PLANT-FORM CLASSES[8/]

Trees	
Alligator juniper	Juniperus Deppeana
One-seed juniper	J. monosperma
Pinyon	Pinus edulis
Utah juniper	Juniperus osteosperma
Long-lived shrubs, yuccas, and cacti	
Baccharis	Baccharis spp.
Bear-grass	Nolina microcarpa
Prickly-pears	Opuntia spp.
Salt-bush	Atriplex canescens
Shrubby buckwheat	Eriogonum Wrightii
Shrubby penstemon	Penstemon linarioides
Squaw-bush	Rhus trilobata
Winter-fat	Eurotia lanata
Yuccas	Yucca spp.
Perennial midgrasses	
Black grama	Bouteloua eriopoda
Galleta	Hilaria Jamesii
Mutton grass	Poa Fendleriana
Sand drop-seed	Sporobolus cryptandrus
Side-oats grama	Bouteloua curtipendula
Squirrel-tail	Sitanion Hystrix
Three-awns	Aristida spp.
Perennial short grasses	
Blue grama	Bouteloua gracilis
Creeping muhly	Muhlenbergia repens
Hairy grama	Bouteloua hirsuta
Texas-timothy	Lycurus phleoides
Perennial tall, mid, and short forbs	
Asters	Aster spp. (mainly arenosus)
Desmanthus	Desmanthus Cooleyi
Globe-mallows	Sphaeralcea spp.
Wild-buckwheats	Eriogonum spp.
Perennial prostrate grasses and forbs	
Ring muhly	Muhlenbergia Torreyi
Half-shrubs	
Snake-weed	Gutierrezia Sarothrae
Twin-berry	Menodora scabra
Inferior annual grasses and forbs	
Aplopappus	Aplopappus gracilis
Resin-weed	Viguiera annua
Russian-thistle	Salsola Kali
Spurges	Euphorbia spp.

8/ Plant names are those published in "Arizona Flora" by Thomas H. Kearney, Robert H. Peebles, and collaborators. University of California Press, 1032 pp., 1951.

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